

Thermal degradation kinetics of nutrients in Citrus juice

Citrus fruits are a highly valued product representing a significant source of antioxidants as vitamin C and carotenoids that could contribute to the beneficial health effects of Citrus juice. In order to study the influence of thermal treatments on these nutrients, thermal degradation kinetics of both vitamin C and carotenoids was determined in a Citrus juice.

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Materials et methods

A mix of juice ratio 3/1 of orange and mandarin species (*Citrus sinensis* L.Osbeck and *Citrus clementina* Hort.ex Tan) from Mediterranean area was heated in a temperature range 50-100°C for vitamin C and 75-100°C for carotenoids. Ascorbic acid and carotenoids were analysed using HPLC¹. The classical kinetic model (a) is based on reaction defining a reaction rate constant (k) that depends on the temperature via an Arrhenius law (Ea). The predicting model (b) based on the kinetics parameters D₁, z, was developed and validated nutrient losses.

$$(a) \quad \ln\left(\frac{C}{C_0}\right) = -k_{\infty} \int e^{-\frac{E_a}{RT}} dt \quad (b) \quad \log_{10}\left(\frac{C}{C_0}\right) = -\frac{1}{D_0} \int 10^{\frac{T}{z}} dt$$

Résultats et discussion

Thermal carotenoids degradation at 55 °C revealed two groups in function of their heat sensitivity. A first group including provitaminic carotenoids displayed a higher heat stability (losses < 10 %) and a second group heat sensitive concerning high-oxygenated xanthophylls (losses between 40-70 %) (figure 1).

Analysis of kinetic data suggested a first order reaction for both the degradation of ascorbic acid and provitamin A carotenoids (figure 2). Arrhenius law and z factor fitted well the temperature dependence of k and D respectively for the three nutrients (table 1). Although, Ea of ascorbic acid agreed with literature, the degradation rates were surprisingly very low in citrus juice tested. Using Ea or z value as indicators for thermal sensitivity, β-carotene was the carotenoid the most stable compared to β-cryptoxanthin.

The nutrients estimations losses calculated according the model were closed to the experimental values (table 2). The developed models can then be easily used as tools to predict losses during whatever heat treatment, for example isothermal (figure 3).

Figure 1. Thermal degradation of carotenoids from citrus juice at 55 °C after 60 min. Group I: thermostable compounds. Group II: heat sensitive compounds.

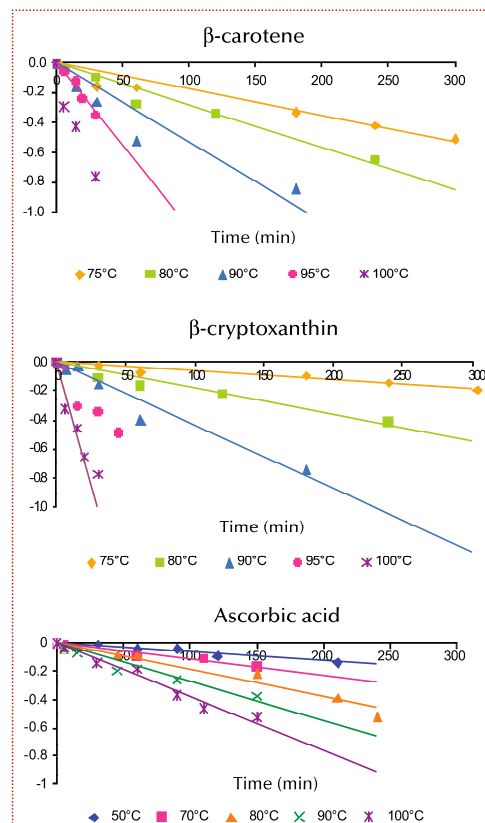
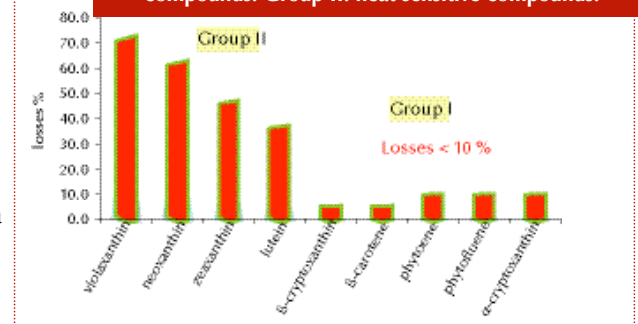


Figure 2. Thermal degradation kinetics of nutrients vs. temperature in citrus juice. A. β-carotene. B. β-cryptoxanthin. C. ascorbic acid.

Table 1. Values of the parameters of the models used to represent the degradation kinetics of the nutrients in citrus juice.

	T range (°C)	Ln-k _∞ (k. s ⁻¹)	E _a (kJ.mol ⁻¹)	log ₁₀ D _{80°C} (s)	z (°C)
β-carotene	75 - 100	27.415	110	8.267	22.5
β-cryptoxanthin	75 - 100	42.410	156	10.028	15.9
Ascorbic acid	50 - 100	1.814	35.9	6.139	64

Table 2. Comparison between experimental and calculated losses of nutrients during isothermal treatments.

Nutrient	Heat treatment T (°C) / t (min)	Losses (%)		
		Experimental	classical model	D/z model
β-carotene	85 / 120	36.5 ± 2	42.0	41.3
β-cryptoxanthin	85 / 120	35.0 ± 3	29.6	28.7
Ascorbic acid	75 / 30	4.1 ± 0.07	4.5	4.4
	90 / 90	21.4 ± 0.7	20.6	20.5

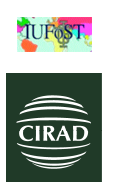
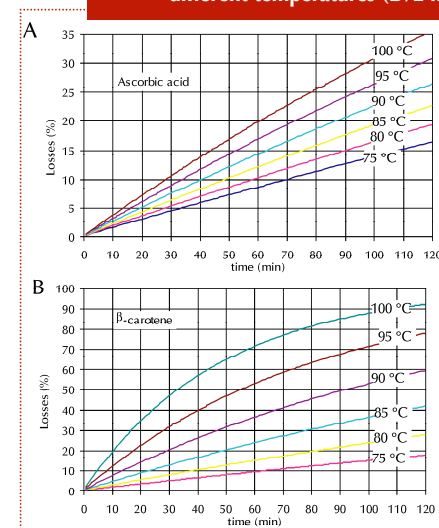
Conclusion

The present findings will help to predict the best processing conditions that minimize degradation of an nutritional factor such as vitamin C and carotenoid in citrus juice. Calculations confirmed that classical pasteurization treatments do not damage significantly the nutrients studied. Nutrient losses should be below 2 % for a pasteurization at 85 °C / 5 min.

Références

1Dhuique-Mayer C., Caris-Veyrat C., Ollitrault P., Curk F. and Amiot M.J. (2005) Varietal and inter-specific influence on micronutrient contents in citrus from the Mediterranean area. Journal of Agricultural and Food Chemistry, 53, 2140-2145.

Figure 3. Estimated losses for ascorbic acid (A) and β-carotene (B) during isothermal treatments at different temperatures (D/z model).



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